Bell Work
16/17-Feb-2016

1. **What is energy, in your own words?**
2. **When do you use energy?**
3. What would you do to find the mass of Fe formed if you had 3.0g of Al and 3.0g of Fe_2O_3?

$$Fe_2O_3 + Al \rightarrow Al_2O_3 + Fe$$

Agenda

What we will learn the next two (2) weeks

Energy, forms and types

Thermochemistry vocabulary

Objective:

You will know what energy is and the forms we use

Thermochemistry

Energy

1st Law of Thermodynamics

Enthalpy / Calorimetry

Hess' Law

Enthalpy of Formation

The Nature of Energy

Units of Energy

SI Unit for energy is the **joule, J**:

$$E_k = \tfrac{1}{2}\, m\, v^2 \rightarrow \tfrac{1}{2}\,(2kg)\,(1m/s)^2 \rightarrow 1kg\ m^2\ s^{-2} = 1\ J$$

Sometimes the calorie is used instead of the joule:

1 cal = 4.184 J (exactly)

A nutritional Calorie:

1 Cal = 1000 cal = 1 kcal = 4.184 kJ

"Food"

"Science"

Thermochemistry Terminology

System: part of the universe we are interested in.

Surrounding: the rest of the universe.

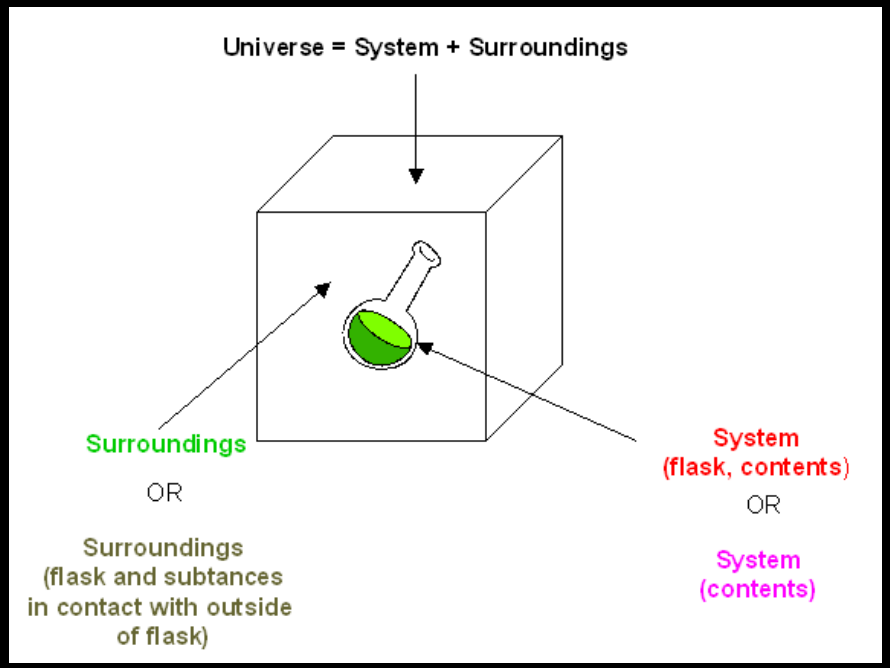
Exothermic: energy released by system to surrounding.

Endothermic: energy absorbed by system from surr.

Work (w): product of force applied to an object over a distance.

Heat (q): transfer of energy between two objects

System vs Surroundings



The First Law of Thermodynamics

"Energy is always conserved, it cannot be created or destroyed. In essence, energy can be converted from one form into another."

Internal Energy

Internal Energy: total energy of a system.

Involves translational, rotational, vibrational motions.

Cannot measure absolute internal energy.

Change in internal energy, $\Delta E = E_{final} - E_{initial}$

The First Law of Thermodynamics

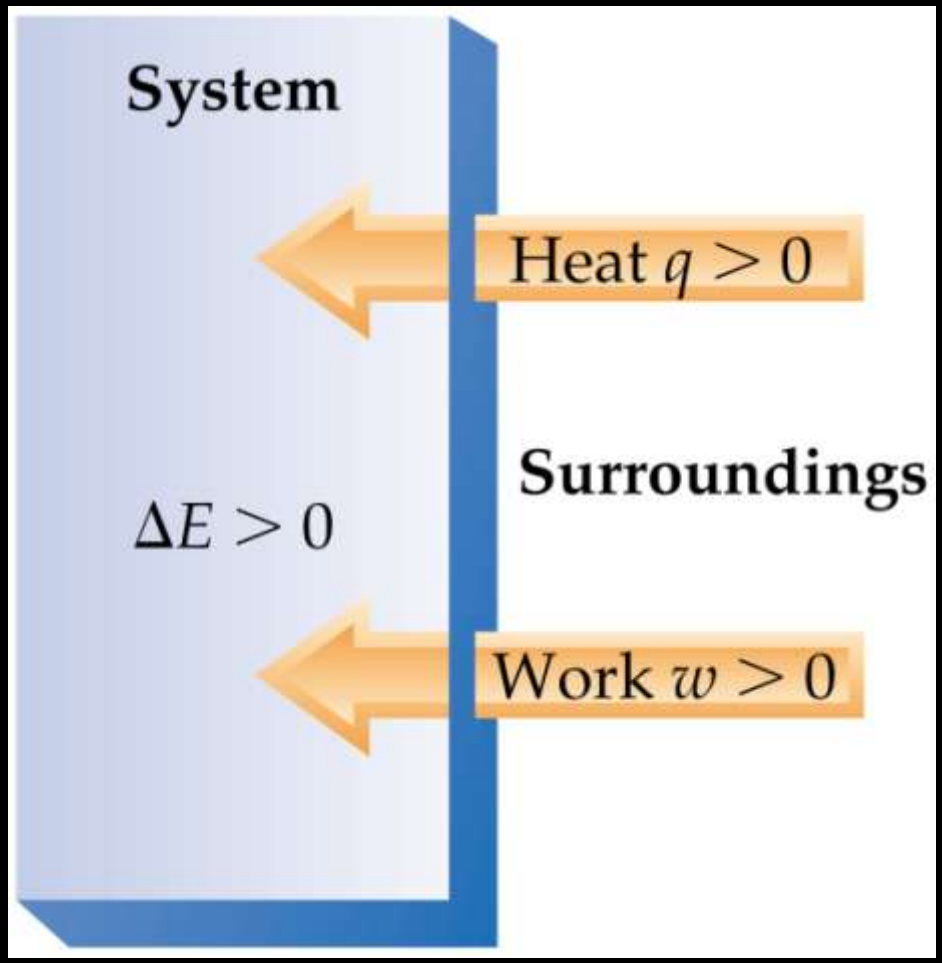
Relating ΔE to Heat(q) and Work(w)

1. Energy cannot be created or destroyed.
2. Energy of (system + surroundings) is constant.
3. Any energy transferred from a system must be transferred to the surroundings (and *vice versa*).

From the first law of thermodynamics:

$$\Delta E = q + w$$

The First Law of Thermodynamics



The First Law of Thermodynamics

Exothermic and Endothermic Processes

Endothermic: absorbs heat (**q**) from the surroundings.

An endothermic reaction feels cold.

Exothermic: transfers heat (**q**) to the surroundings.

An exothermic reaction feels hot.

The First Law of Thermodynamics

Exothermic process is any process that gives off heat – transfers thermal energy from the system to the surroundings.

$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l)$ + energy

$H_2O\,(g) \rightarrow H_2O\,(l)$ + energy

Endothermic process is any process in which heat has to be supplied to the system from the surroundings.

energy + $2HgO\,(s) \rightarrow 2Hg\,(l) + O_2\,(g)$

energy + $H_2O\,(s) \rightarrow H_2O\,(l)$

Practice

How many joules are in a 290Cal candy bar?

1Cal = 4.184kJ

Calorimetry

Heat Capacity and Specific Heat

Calorimetry = measurement of heat flow.

Calorimeter = apparatus that measures heat flow.

Heat capacity = the amount of energy required to raise the temperature of an object (by one degree).

Molar heat capacity = heat capacity of 1 mol of a substance.

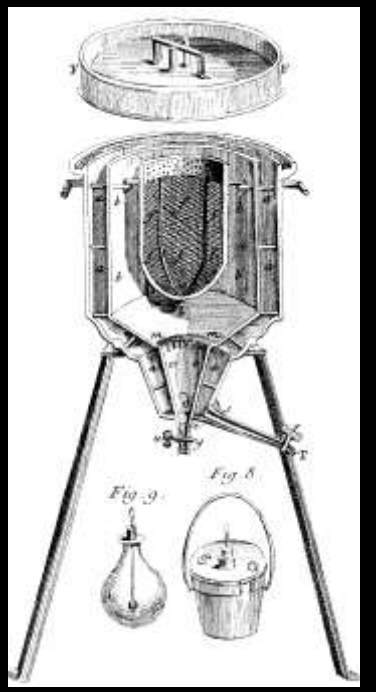
Specific heat (C_p) = specific heat capacity = heat capacity of 1 g of a substance.

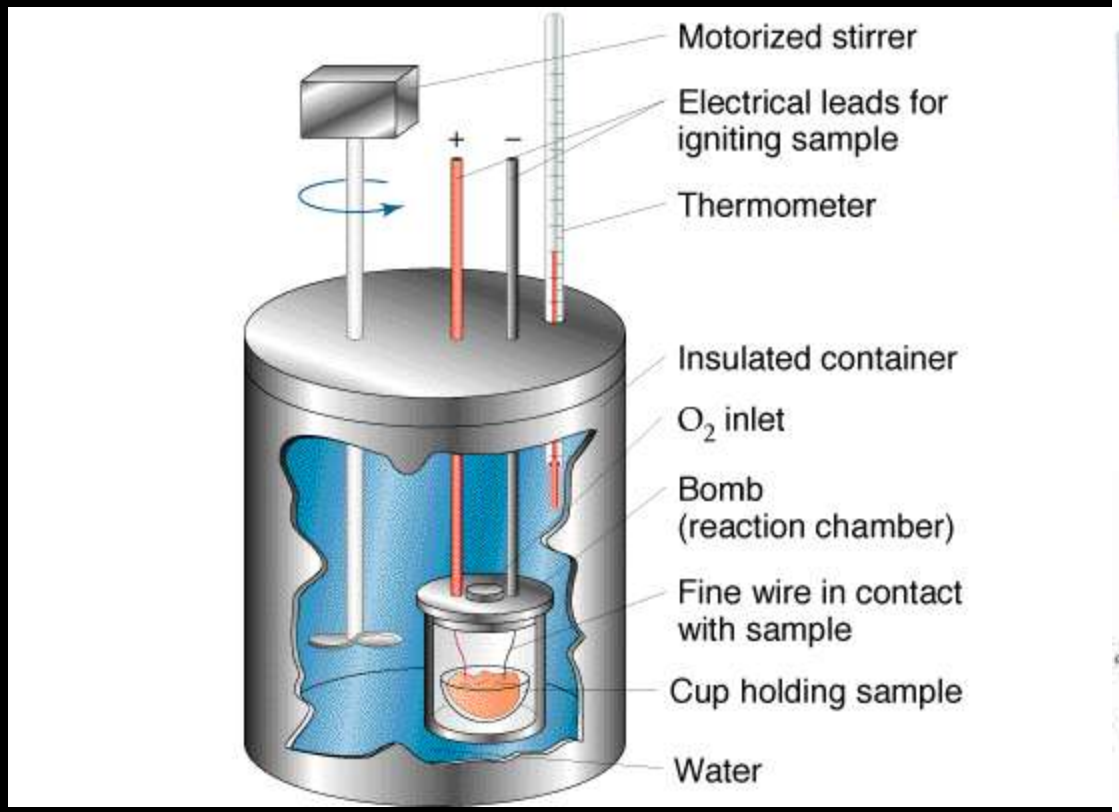
q = (specific heat)x(grams of substance) x (change in temp)

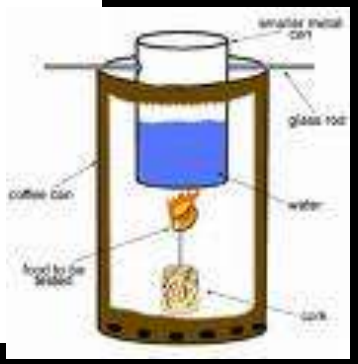
$$q = (C_p) \times (m) \times \Delta T$$

Calorimetry

Calorimeter = apparatus that measures heat flow.







Calorimetry

Heat Capacity and Specific Heat

Specific heat of a substance is defined at the amount of heat that must be absorbed or lost for 1 g of that substance to change its temperature by 1°C

Consider the specific heat of Cu, 0.385 J/g°C. What this means is that it takes 0.385 J of heat to raise 1 g of Cu 1 °C. Thus, if we take 1 g of Cu at 25°C and add 0.385 J of heat to it, we will find that the temp. of the Cu will have risen to 26°C

$$q = C_p \times m \times \Delta T$$

Substance	**C_p (J/ g °C)**
$N_2(g)$	1.04
Al(s)	0.902
Fe(s)	0.45
Hg(l)	0.14
$H_2O(l)$	4.184
$H_2O(s)$	2.06
$CH_4(g)$	2.20
$CO_2(g)$	0.84
Wood , Glass	1.76 , 0.84
Ceramic Tile	140 000

q_{feet} → Tile

Needs lot of “q” to raise temp of tile even 1°C, b/c heat capacity of ceramics is so high

q_{feet} → alpaca

Very little “q” to raise temp of alpaca even 1°C, b/c heat capacity of alpaca is so low

Together

What amount of energy will it take to raise a 20g piece of Fe by 5°C if the specific heat of Fe is 0.45 J/g°C?

$m = 20g$

$\Delta T = 5°C$

$C_p = 0.45\ J/g°C$

$q = ?$

$q = C_p \times m \times \Delta T$

$q = (0.45\ J/g°C)\ (20g)(5°C)$

$q = 45\ J$

Bell Work
16/17 Feb 2016

What are the three (3) parts of the first law of thermodynamics?

Agenda

"Energy of Peanut"

Objective:

Lab Time

"Energy of a Peanut An experiment in Calorimetry"

IF YOU HAVE A FOOD ALERGY TELL MR. GOLDEN

Nutrition Facts **Serving Size: 28g**	
Amount per Serving	
Calories 160	**Calories from Fat 130**
	% Daily Value *
Total Fat 14g	22%
Saturated Fat 2g	10%
Monounsaturated Fat 7g Polyunsaturated Fat 4g Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 85mg	4%
Total Carbohydrate 5g	2%
Dietary Fiber 2g	9%
Sugars 1g	
Protein 7g	14%

Lab Time

Goldfish
Serving Size 30g

Nutrition Facts

Serving Size: 60 pieces

Amount Per Serving	
Calories 140	Calories from Fat 45
	% Daily Value*
Total Fat 5 g	8%
Saturated Fat 1 g	5%
Trans Fat 0 g	
Cholesterol 5 mg	2%
Sodium 170 mg	7%
Potassium	
Total Carbohydrate 20 g	7%
Dietary Fiber 1 g	4%
Sugars 1 g	
Sugar Alcohols	
Protein 4 g	
Vitamin A 0 IU	0%
Vitamin C 0 mg	0%
Calcium 100 mg	10%
Iron 0.72 mg	4%

"Peanut"

Nutrition Facts **Serving Size: 28g**	
Amount per Serving	
Calories 160	**Calories from Fat 130**
	% Daily Value *
Total Fat 14g	22%
Saturated Fat 2g	10%
Monounsaturated Fat 7g Polyunsaturated Fat 4g Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 85mg	4%
Total Carbohydrate 5g	2%
Dietary Fiber 2g	9%
Sugars 1g	
Protein 7g	14%

Energy of a Peanut

	Peanut		Other Snack Sample	
	Trial 1	Trail 2	_____	_____
Mass of sample	g	g	g	g
Mass of remaining material	g	g	g	g
Mass of sample that burned	g	g	g	g
Initial Temp	°C	°C	°C	°C
Final Temp	°C	°C	°C	°C
Volume of Water	ml	ml	ml	ml
Mass of water	g	g	g	g

Energy of a Peanut

Heat produced by sample Joules	J	J	J	J
Heat produced by sample calories	cal	cal	cal	cal
Heat produced by 1 gram of sample	cal	cal	cal	cal
Kilocalories of heat from 1 gram of samples	kcal	kcal	kcal	kcal
Serving size (from label)	g	g	g	g
"Calories" per serving size (from label)	Cal	Cal	Cal	Cal
"Calories" per gram (from label)	Cal/g	Cal/g	Cal/g	Cal/g

From food label

Your Turn ☺

What amount of energy will it take to raise a 45g piece of Al by a temperature of 27°C to 35°C if the specific heat of Al is 0.902 J/g°C?

m = 45g

ΔT = 35°C - 27°C→ 8°C

C_p = 0.902 J/gºC

q = ?

q = C_p x m x ΔT

q = (0.902 J/g°C) (45g)(8°C)

q = 324.7 J

Together

If 242 J is used to warm a piece of Al with a mass of 25g, what is the final temperature of the Al if its initial temperature is 5.0°C?

$m = 25g$

$T_f = ?$

$T_i = 5°C$

$C_p = 0.902\ J/g°C$

$q = 242J$

$q = C_p\ m\ (T_f - T_i)$

$T_f = q/(C_p \times m) + T_i$

$T_f = 242J/ (0.902\ J/g°C \times 25g) + 5°C$

$\Delta T = 15.73°C$

Your Turn ☺

What mass of Au can be raised 15°C by 500J; specific heat of Au is 0.129 J/g°C?

m = ?

ΔT = 15°C

C_p = 0.129 J/g°C

q = 500J

$q = C_p\ m\ \Delta T$

$m = q/(C_p \times \Delta T)$

m = 500J/ (0.129 J/g°C x 15°C)

m = 258g

On your Own

The following acid-base reaction is performed in a coffee cup calorimeter:

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

The temperature of 110 g of water ($C_p = 4.184$ J/°Cg)

rises from 25.0°C to 26.2°C when 0.10 mol of H^+ is reacted with 0.10 mol of OH^-. Calculate q_{water}

If the specific heat of methanol is 2.20 J/°Cg, how many joules are necessary to raise the temperature of 250 g of methanol from 18°C to 33°C?

Class Data

Experimental Data	Peanut		
	Trial 1	Trial 2	Trial 3
Mass of sample	g	g	g
Mass of remaining material	g	g	g
Mass of sample that burned	g	g	g
Initial Temperature Water	°C	°C	°C
Final Temperature Water	°C	°C	°C
Change in Temperature water (ΔT)	°C	°C	°C
Volume of Water	ml	ml	ml
Mass of water	g	g	g